UDC 687.3

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# GARMENT DESIGN FOR LONGEVITY: ENGINEERING FOR OPTIMAL CARE AND REPAIRABILITY

***Purpose.*** *The purpose of this study is to systematise design strategies that extend the useful life of apparel by making garments easier to maintain, repair, adapt and recover. Particular attention is paid to design for disassembly, modular construction, durable material selection, emotional durability and digital product information as mutually reinforcing approaches to circular fashion.*

***Keywords:*** *circular fashion, apparel longevity, design for repair, maintenance, modular design, design for disassembly, digital product passport.*

***Objectives.*** The objectives are to identify the main design decisions that influence garment maintainability and reparability; to analyse how modular and disassemblable constructions can reduce premature replacement; to examine the role of material durability and emotional attachment in extending use; and to assess how digital product information can support repair and responsible end-of-life decisions.

***Methodology.*** The study uses qualitative analysis and synthesis of sustainable-fashion and circular-design literature together with comparative examination of constructive solutions presented in the source material. The analysis considers apparel as a product-service system whose longevity depends not only on material resistance, but also on accessibility of components, ease of intervention, adaptability, maintenance requirements and the availability of product information. The proposed framework integrates technical, functional, emotional and informational dimensions of longevity [1–10].

***Research results.*** Apparel longevity should be treated as a design objective established before production rather than as a consequence of material quality alone. A garment may remain physically intact yet be discarded because it is difficult to repair, inconvenient to maintain, aesthetically inflexible or poorly understood by the user. Therefore, design for longevity requires coordination between construction, materials, maintenance, user experience and end-of-life planning [2, 3, 6].

**1. Design for disassembly and repairability**

Design for disassembly (DfD) is one of the most direct strategies for improving garment reparability. It involves designing products so that components can be separated, accessed, repaired, replaced or recycled without damaging the primary structure. In apparel, this principle can be translated into accessible seams, detachable fasteners, removable cuffs and collars, replaceable pocket elements, modular linings and standardised trims. Such solutions allow localised wear to be addressed without replacing the whole product [3, 4, 6].

The practical value of DfD lies in reducing the technical complexity of maintenance. Conventional garments often contain components that are permanently attached, difficult to reach or impossible to replace without visible damage. By contrast, reversible or detachable construction can shorten repair time, lower service costs and preserve the aesthetic integrity of the garment. From a circular-economy perspective, the same principle also improves material recovery because disassembly facilitates the separation of textile substrates from zips, buttons, linings and other components before recycling [3, 7].

Repairability should therefore be considered as a measurable design characteristic. During product development, designers can assess whether highly exposed areas can be reached from the inside, whether worn components are individually replaceable, whether standard tools are sufficient for intervention and whether replacement parts can be supplied. This shifts the designer's attention from the moment of sale towards the full use phase of the garment.

**2. Modularity as a strategy for functional and aesthetic longevity**

Modularity extends the logic of repair by allowing a garment to change during use. A modular apparel product is composed of separate or detachable elements that can be replaced, reconfigured or combined in different ways. Examples include removable sleeves, interchangeable hoods, detachable collars, replaceable linings and reversible or transformable decorative elements. When one component wears out, it can be replaced independently; when user needs change, the garment can be adapted instead of discarded [4, 5].

The sustainability value of modularity is not limited to physical durability. It can also prolong functional relevance. A garment that adapts to seasonal conditions, different social contexts or changing aesthetic preferences is less likely to become obsolete while still technically usable. In this sense, modularity creates a bridge between design for repair and design for emotional durability: the product remains open to personalisation and renewal, strengthening the user's motivation to keep it in active use [5, 6].

At the same time, excessive modularity can introduce additional fasteners, components and material combinations. For this reason, the number of modules should be justified by an actual use or repair scenario. The most effective solutions are those that simplify intervention and adaptation without increasing construction complexity or compromising recyclability.

**3. Material durability and maintenance compatibility**

Material selection remains a fundamental condition for longevity. Fabrics intended for long-term use should demonstrate adequate abrasion resistance, dimensional stability, colour fastness and behaviour under repeated laundering or professional cleaning. However, durability must be considered together with maintenance requirements. A technically strong material that needs complex, energy-intensive or highly specialised care may still perform poorly from a lifecycle perspective because maintenance can become expensive or inconvenient for the user [2, 5].

The choice between natural, synthetic, recycled and hybrid materials should therefore be made on the basis of the intended product category and use pattern rather than by treating one fibre group as universally superior. Natural fibres can offer comfort and biodegradability, whilst synthetic fibres can provide high mechanical performance and elasticity. Recycled and hybrid textiles can combine functional performance with lower demand for virgin inputs, but their end-of-life pathways must also be considered [2, 7, 8].

A longevity-oriented material specification should link the textile to its maintenance scenario: how often the product will be washed, which areas are most exposed to wear, whether components can be replaced, and whether the fabric can withstand repeated repair. This approach treats maintenance as part of product design rather than as information added only after production.

**4. Emotional durability and consumer attachment**

Physical durability alone does not guarantee prolonged use. Consumers may discontinue use of garments that remain technically serviceable because the products lose aesthetic relevance, no longer correspond to personal identity or fail to create a meaningful relationship with the wearer. Emotional durability addresses this problem by considering the psychological and symbolic reasons for keeping a product [6].

In apparel design, emotional attachment can be encouraged through timeless visual solutions, customisation, transformability, visible repair, personalisation and brand narratives that give the garment a distinctive history. Repair itself can become part of this relationship: a visible or creative repair may transform damage into evidence of continued use and individual ownership rather than being

perceived merely as a defect. This principle supports the transition from passive consumption towards active stewardship of clothing [2, 6, 9].

For brands, services such as repair, alteration, refurbishment and component replacement can therefore create value beyond the initial sale. These services keep the product within the brand ecosystem, strengthen contact with the customer and make longevity visible as part of the product proposition rather than as an abstract sustainability claim.

**5. Digital product information as an enabler of maintenance and repair**

The digital product passport can complement physical design strategies by ensuring that information required for maintenance and repair remains accessible throughout the product lifecycle. A digital record linked through a QR code or another identifier may contain fibre composition, care instructions, component information, repair guidance, spare-part specifications and records of interventions. In this way, information that is often lost when labels are removed or damaged can remain available to users, repair services and recyclers.

For maintenance, the principal value of digital information is precision. Generic care labels provide only a limited set of instructions, whereas a digital profile can communicate product-specific advice: which seam can be opened for access, which component can be replaced, how a modular element is detached, or which material combinations require separate handling. At end of life, the same information can support sorting and material recovery by clarifying the composition of the product and its components.

The effectiveness of such systems depends on information quality and usability. A digital passport is useful only when the data are understandable, updated where necessary and linked to realistic maintenance or repair actions. Therefore, digitalisation should not replace repair-oriented construction; it should make the technical intentions of the design more transparent and actionable for the user.

**6. Integrated framework for apparel longevity**

The analysis indicates that the strongest longevity strategy is not a single design technique but an integrated combination of complementary measures. Design for disassembly improves access; modularity enables replacement and adaptation; material selection supports repeated use and care; emotional design encourages continued ownership; and digital information connects users and service providers with the knowledge needed to maintain the product. These dimensions can be combined into a practical design framework for apparel development.

Table 1 – **Design framework for apparel longevity**

| Design dimension | Key design decision | Maintenance/repair effect | Longevity contribution |
|---|---|---|---|
| Disassembly | Accessible and detachable components | Simplifies local repair and replacement | Reduces premature disposal |
| Modularity | Interchangeable or transformable elements | Allows partial replacement and adaptation | Extends functional relevance |
| Materials | Durable, care-compatible textiles | Supports repeated cleaning and intervention | Maintains physical performance |
| Emotional design | Personalisation and aesthetic continuity | Encourages repair and continued use | Strengthens attachment |
| Digital information | Product-specific care and repair data | Improves access to instructions and parts data | Supports maintenance and end-of-life decisions |

The framework is intended for use during the early design stage, when decisions about seams, component interfaces, material combinations and information architecture are still flexible. Applying the framework after a garment has already been industrialised is less effective because reparability is then constrained by decisions that have already been fixed. For this reason, maintenance and repair should be treated as design requirements alongside fit, appearance, manufacturability and cost.

The framework also suggests a change in the role of the designer. Rather than designing only the initial product configuration, the designer anticipates future interventions: cleaning, adjustment, replacement, repair, transformation, resale and material recovery. This broader perspective is consistent with circular-design approaches in which value is retained by keeping products and materials in use for longer [3, 7, 10].

***Conclusion.*** The study confirms that apparel longevity depends on a combination of physical durability, maintainability, reparability, adaptability and continued user value. Design for disassembly and modular construction reduce the technical barriers to intervention; appropriate material selection supports repeated use and care; emotional design increases the likelihood that consumers will retain and repair garments; and digital product information can make maintenance and end-of-life decisions more informed. The most effective approach is therefore integrated rather than isolated: repairability must be embedded in construction, supported by materials and information, and reinforced by product-service relationships. For fashion design practice, this means that maintenance and repair should be specified as explicit design criteria from the earliest development stages. Such an approach can extend the active life of garments, reduce premature replacement and support the broader transition from a linear model of consumption towards circular use of apparel resources.

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